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16. ABSTRACT

RECENT LEGISLATIVE CHANGES

An aspect of the amended (1985) U.S. Superfund Program is the authority to conduct research and demonstration as described here.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The five-year schedule for the minimization and restrictions on the disposal of hazardous wastes onto the land is described.

TRENDS IN THE UNITED STATES FOR THE MANAGEMENT OF HAZARDOUS WASTES

Public scrutiny can result in long delays or a prohibition against permitting waste management facilities.

Two major items are causing a shift in the way hazardous wastes are managed in the United States. Because of liability for hazardous wastes, companies are seeking methods which will detoxify or destroy these wastes. Under the RCRA amendments, best demonstrated available technology (BDAT) is being determined for each waste stream and is considered here.

CURRENT TECHNOLOGIES--THEIR PROBLEMS

A description of the types of wastes not readily treated by current technologies and some of the deficiencies of these technologies are covered.

ESTABLISHED TECHNOLOGIES

Description of technologies currently used in the Superfund SITE Program.

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ALTERNATIVE TREATMENT METHODS FOR HAZARDOUS WASTES

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RECENT LEGISLATIVE CHANGES

The Superfund Authority Reauthorization Act (SARA) amendments of 1986 re-established the Superfund Program in the United States. It calls for an expenditure of $8.5 billion over the next five years to clean up abandoned hazardous waste sites. One significant aspect of this legislation was the newly-established authority to conduct research and demonstration under this Act. The Environmental Protection Agency in responding to this authority, has established a technology research, demonstration, and evaluation program to promote the development and use of innovative technologies to treat Superfund and hazardous wastes. This is the Superfund Innovative Technology Evaluation (SITE) Program. The Act authorized a technology demonstration program through 1991 at a level of up to $20 million per year. The program will help provide the treatment technologies necessary to implement new cleanup standards that require a greater reliance on permanent remedies at Superfund sites. The EPA's major focus is a demonstration program to provide sound engineering and cost data on selected technologies. These data will resolve issues standing in the way of actual full-scale application.

The demonstration program represents a unique partnership between EPA and technology developers. Although the early projects involve no Federal funding for developers, a mutually beneficial relationship is established for both parties. Developers are responsible for mobilizing their units and operating them at selected sites. These may be Superfund sites. developer's facilities, EPA laboratories, or private sites. EPA is responsible for sampling, analysis, and evaluation of test results. The developers are provided extensive data that validate their capabilities while EPA is able to assess the performance, reliability. and cost of technologies. This information will be used directly by Regional and State personnel responsible for the selection of remedies and responses at Superfund sites.

The Emerging Technologies portion of the SITE program will foster the further development of technologies that are not yet ready for full-scale demonstration. The goal is to ensure that a steady stream of more permanent, cost-effective technologies will be ready to be demonstrated in the field, thereby increasing the number of viable alternatives available for use in Superfund cleanups. This program will deal with innovative technologies for recycling, separation, detoxification, destruction, and stabilization of hazardous chemical wastes.

Two-year funding will be provided through competitive cooperative agreements to technology developers that take promising bench/laboratory-scale technologies to the pilot scale. The program will make up to $150,000 per year, for a maximum of $300,000 over two years, available to selected individual technology developers. In order to obtain second-year funding, significant progress must be made during the first year.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The 1984 amendments to RCRA established a principle of restricting and minimizing the land disposal of hazardous wastes. These restrictions are significant and carry strict timetable "hammer dates." The so-called land ban restrictions set up a 5-year program to establish treatment standards that wastes must meet before being land disposed. A timetable for each group is given in Table 1.

Table 1. Land Ban Restrictions Timetable.

Dioxins and Solvents	November 8, 1986
California List (Metals and Cyanides, Corrosives, Halogenated Organics)	July 8, 1987
First-Third of Remaining Hazardous Wastes	August 8, 1988
Second-Third of Remaining Hazardous Wastes	June 8, 1989
All Hazardous Wastes	May 8, 1990

The RCRA legislation requires mandatory notification of waste generation and the manifesting of waste shipments. These requirements and the permits required for storage, treatment, and disposal facilities have created cradle-to-grave control of these wastes. This waste management approach has created a real opportunity for the development of adequate and cost effective treatment methods. For many of the wastes generated, a process to adequately treat them cost-effectively or that has sufficient capacity to handle the waste volume is absent. This technology vacuum provides a true incentive and opportunity to develop and market new technologies.

TRENDS IN THE UNITED STATES FOR THE MANAGEMENT OF HAZARDOUS WASTES [1]

Two major concerns are causing a shift in the way hazardous wastes are managed in the United States - legal liabilities and regulatory standards. Companies no longer want to have a future liability for hazardous wastes that are generated from their processes. Because of this, they are seeking methods which will detoxify or destroy these wastes, thereby eliminating any possible future liability. Citizens are becoming more informed and more demanding of companies that wish to dispose of wastes in their areas. These demands result in considerable public scrutiny of how the wastes will be handled, and can result in long delays or a prohibition against permitting of these facilities. Public concern has extended even to the transporting or the terminal transfer of wastes within their area. As a result of the RCRA amendments, best demonstrated available technology (BDAT) is being determined for each waste stream. BDAT is the legal term for a set of treatment targets defined by EPA's Office of Solid Waste as part of the Land Disposal Restriction Program.

To establish BDAT, EPA's preference is to go to an industrial establishment that has a treatment technology to be examined and/or that generates the particular waste stream for which the standard is to be developed. Through a performance evaluation of that technology, the degree to which the waste can be treated will be determined. Evaluations of several potentially valid treatment processes may be made for a given waste stream. This quantitative information is then used by EPA's Office of Solid Waste to help establish a BDAT limit, i.e., technology-based regulatory levels. It has been found that there are treatment plants presently treating waste streams and producing a residue that will require further treatment to meet the new limit being established. The Agency is concerned not only with the residuals that will be going to the land but with air emissions and liquid effluents as well. New air emission standards are

being developed for hazardous waste treatment, storage and disposal facilities. The wastewater standards will depend on whether the discharge is direct to a water course or to a publicly-owned treatment works. A similar series of evaluations is being conducted on technologies for a variety of Superfund waste streams.

As the waste BDAT levels are established, it is likely that the treatment residuals will be required to pass tests before they may be land disposed. The first test is the "paint filter" test. This is to ensure that the waste does not contain free moisture. The Agency is considering two further tests.

One test relates to the land-disposal restriction or BDAT number. For each hazardous component that may be present in a particular listed waste, EPA will establish the maximum constituent concentration permissible in order for that waste to be disposed of on the land in a secure hazardous waste disposal facility. This concentration level will be the lowest concentration that can be achieved through treatment with the BDAT.

The other test is a proposed toxicity characteristic leaching procedure (TCLP) which evaluates the leachability of constituent organics and metals in liquid, solid, and multi-phase wastes. This test is to identify wastes which pose a hazard due to their potential to leach significant concentrations of specific toxic species, or to mobilize other toxicants. The EPA used the drinking water standards for eight elements and six pesticides as the basis of the EP Toxicity Procedure. The TCLP uses different risk levels for carcinogens and compound-specific toxicity levels from exposure assessment data. If the leachate from the TCLP contains concentrations in excess of the limits established for the toxicant, the waste must be further treated until it passes the test, if it is to be disposed in a non-secured landfill.[2]

CURRENT TECHNOLOGIES--THEIR PROBLEMS [3,4,5]

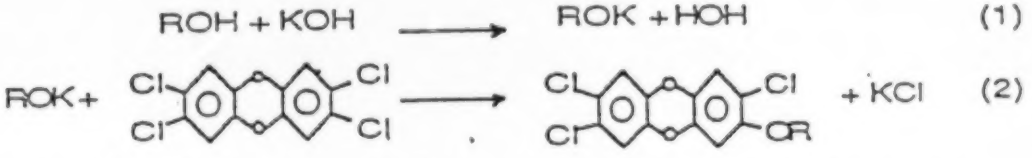
The conventional treatment processes available for industrial waste will provide, in the short term, some technologies useful to the remediation of hazardous waste sites. Unfortunately, reliable data on the performance of these technologies, for many hazardous waste streams, does not exist. Due to the complexity of the wastes and the matrices in which they are found at the many hazardous waste sites, there will be definite limitations to many treatment strategies. While some technologies of physical/chemical and/or biological treatment have had major success with waterborne pollution, they remain to be established as effective technologies for the treatment of hazardous wastes. In many cases, the residuals from these processes continue to present problems. Other problems frequently experienced with existing technologies include: [6]

- o Being limited to aqueous streams containing nonhalogenated contaminants;
- o Not appropriate for solids or very viscous liquids;
- o Relatively low temperatures may not be sufficient for halogenated wastes;
- o Corrosion and fouling of equipment may reduce capacities;
- o High pressures necessitate sophisticated equipment and operational techniques; and
- o The products of reaction could be more hazardous than the original waste stream.

EMERGING TECHNOLOGIES [7]

These technologies can simply be classified into two types--chemical detoxification/destruction and biological detoxification/destruction. There have been notable recent successes in these.

KPEG Process - In the chemical detoxification area our Laboratory's scientists have been developing a chemical reagent called KPEG.[8] This reagent is made by reacting potassium hydroxide with polyethylene glycol (of about molecular weight 400) to form an alkoxide (equation 1 below). The alkoxide reacts with one of the chlorine atoms on the chlorinated molecule to produce an ether and potassium chloride (equation 2 below).



Our efforts have concentrated on very exploratory work and proof-of-concept research for both contaminated liquids and contaminated soils. The brief descriptions of the activities related to the development of the KPEG process are shown in the following three tables.

Table 1. KPEG Process - Exploratory Research

Place/Date:	Bengart & Hemel Buffalo, NY 8/83	Shenandoah Stables, Moscow Mills, MO 10/84
Pollutant:	PCB- Contaminated Soil	PCB- Contaminated Soil
Treated:	Plot 8'x10'	20 Plots 4'x4'
Reactor:	In situ	In situ
Result:	Inconclusive	Inconclusive

Table 2. KPEG Process - Proof-of-Concept Research - Liquids

Place/Date:	Montana Pole, Butte, MT 7/86	Western Processings, Kent, WA 8/86
Pollutant:	PCDD/PCDF-Contaminated Liquids	TCDD-Contaminated Liquids
Treated:	9000 gallons	7550 gallons
Reactor:	2700-gallon	2700-gallon
Result:	Destruction to non-detectible level	Destruction to non-detectible level
	**********	
Place/Date:	Economy Products Co. Omaha, NE 5/87	Fairborn Fire Department Fairborn, OH 7/87
Pollutant:	TCDD-Contaminated Liquids	TCDD-Contaminated 2,4,5-T Liquids
Treated:	20 gallons	1 gallon
Reactor:	55-gallon drums	1 gallon
Result:	Destruction to non-detectible level	Destruction to non-detectible level

TABLE 3. KPEG Process - Proof-of-Concept Research - Soils

Place/Date:	Bengard & Memel Buffalo, NY 2/87	General Electric South Glen Falls, NY 6/87
Pollutant:	PCB-Contaminated Soil	PCB-Contaminated Soil
Treated:	10,000 pounds	350 pounds
Reactor:	55-gallon drum	40 gallon (EPA)
Results:	Destruction to non-detectible levels	Destroyed PCBs to less than 10 ppm.

The Hazardous Waste Engineering Research Lab in Cincinnati, Ohio is continuing in its development of the KPEG process through tests on contaminated soils

in a larger scale reactor. The new reactor has a 400-gallon capacity so that scale-up in terms of expected performance, pretreatment considerations and costs can be predicted with confidence. Six tests are currently planned. They are shown in the following Table 4.

Table 4. KPEG Process-Planned Pilot Plant Tests

Place:	U.S. Navy Public Works Center, Guam	U.S. Navy Power Plant, Guam
Pollutant:	PCB Contaminated Soil	PCDD/PCDFs and PCBs in liquids
To be Treated:	30 Tons	150-gallon drums
Reactor:	400 Gallons (EPA)	55-gallon drum
Place:	Disposal Site-Wide Beach, NY	Disposal Site-Wide Beach, NY
Pollutant:	PCB-Contaminated Soils	PCB-Contaminated Soils
To be Treated.	1 Ton	30 Tons
Reactor:	40-gallon (EPA)	400-gallon (EPA)
Place:	MGM Break, Cloverdale, CA	U.S. Navy Honolulu, HI
Pollutant:	PCB-Contaminated Soils	PCB-Contaminated Soils
To be treated:	200 pounds	10 Tons
Reactor:	40-gallon (EPA)	400-gallon (EPA)

In the course of the developmental work on KPEG, bioassay tests were conducted that could determine the effect of KPEG by-products on living organisms. Such tests included: (a) mutagenicity assays (such as the Salmonella or Ames test), which determines whether the by-products cause cell

mutations, (b) toxicity studies, which determine whether the by-products cause any immediate harm (including death) to organisms, and (c) bioaccumulation/ bioconcentration tests, which determine whether an organism accumulates or concentrates the by-products in the tissues of organisms. The results of these bioassays indicate that the by-products produced between KPEG reagents and the pollutants studied (including TCDD) do not bioaccumulate or bioconcentrate, they do not cause mutagenicity, nor are they toxic to aquatic organisms or mammals.

BIOSYSTEMS FOR POLLUTION CONTROL

Biological detoxification of hazardous wastes is largely an underdeveloped technology.[9] Although there are a number of private firms currently operating in the United States that use biosystems for pollution control, many of these technologies are based on proprietary consortia of bacterial species. The use of these consortia is based in part on the limitations of single species to sufficiently degrade specific wastes. Each species of the bacterial community plays a role in the overall degradation of the waste with the inadequacies of one offset by the abilities of another. A number of anticipated problems face the successful use of biosystems for pollution control. These include a large variety of recalcitrant compounds that are either toxic to the organisms or very refractory or the fact that the wastes come in mixed forms, therefore creating a variety difficult to treat. Concern for the by-products that result from these treatments is essential so that the treatment not result in a troublesome compound. Many waste sites involve very difficult matrices which make it difficult to deliver organisms to the waste, ensure their survival and/or determine whether the complete treatment has been achieved.

These technical problems, in tandem with public concerns and regulatory constraints, present a formidable barrier to widespread use of biological systems. The U.S. EPA has a program underway to address these problems and to promote the use of biological systems for pollution control. [10] Our program consists of the following six components:

- Characterize biodegradation processes.
- Develop biosystems.
- Establish engineering factors.
- Determine environmental fate and effects.
- Eliminate adverse consequences.
- Transfer information

The program is being conducted jointly by a number of EPA Laboratories. Specific tasks that are planned for the immediate future consist of the following:

Field Applications -

- in situ biodegradation of oily hazardous waste using nitrate as a terminal electron acceptor.
- Demonstrate the degradation of effluents containing complex chemical mixtures by Phanerochaete chrysosporium using a rotating biological contactor.

Research projects leading to field tests in FY89 -

- anaerobic degradation of trichlorethylene by strain G-4, using a vapor phase treatment system.
- anaerobic degradation of PCBs by genetically engineered organisms using innoculation into contaminated soils and eventually into aerated lagoons.
- decontamination of materials containing 2,4,5-T, 2,4-D, and dioxins using combined technologies of chemical and biological degradation.
- biodegradation of complex chemical mixtures by P. chrysosporium using land farming techniques.
- anaerobic dehalogenation using a consortia to degrade Pentachlorophenol.
- anaerobic degradation of PCBs in estuarine sediments.

Biosystems Protocol

- Probably most importantly, a protocol document will be developed that will enable individuals to have a consistent approach to evaluating the efficacy of a biosystem for a particular pollutant problem.

We believe that our demonstrations in the field over the next several years will promote and illustrate the usefulness of biosystems for solving many of the environmental problems we face today.

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